

What is claimed is:

1. A method for determining a two phase flow rate of a fluid mixture through a vessel, said fluid mixture comprising at least a first fluid component characterized by a first phase and a second fluid component characterized by a second phase, the method comprising:
 - A. performing a tomography measurement of said fluid mixture flowing through said vessel so as to determine a ratio ρ between said first component and said second component within said fluid mixture;
 - B. obtaining a first approximate flow measurement and a second approximate flow measurement by using a first and a second transducer sensor to transmit a wave through said fluid mixture and detect the transmitted wave; and
 - C. computing said two phase flow rate of said fluid mixture as a known function of said ratio ρ , said first and second flow measurements, and the direction and speed of transmission of said wave.
2. A method in accordance with claim 1, wherein said tomography measurement comprises an ECT (Electrical Capacitance Tomography) measurement.
3. A method in accordance with claim 1, wherein the step of determining said ratio of said first component to said second component comprises the step of measuring a distribution of dielectric permittivity within said vessel.
4. A method in accordance with claim 3, wherein the step of measuring a distribution of dielectric permittivity within said vessel comprises measuring the electrical capacitances between one or more pairs of electrodes placed around the periphery of a capacitance tomography unit.
5. A method in accordance with claim 1, wherein at least one transducer sensor comprises an ultrasound sensor, and wherein said wave comprises an ultrasound wave.

6. A method in accordance with claim 1, wherein said at least one transducer sensor comprises:
 - a) a first ultrasound sensor for providing said first flow measurement, and
 - b) a second ultrasound sensor for providing said second flow measurement, and wherein said wave comprises a first ultrasound wave propagating at an angle with respect to the direction of flow of said fluid mixture, and a second ultrasound wave propagating at another angle with respect to the direction of flow of said fluid mixture.
7. A method in accordance with claim 6, wherein said first ultrasound sensor comprises a first ultrasound transmitter for generating said first ultrasound wave and transmitting it through said fluid mixture, and a first ultrasound receiver for receiving said transmitted ultrasound wave; and wherein said second ultrasound sensor comprises a second ultrasound transmitter for generating said second ultrasound wave and transmitting it through said fluid mixture, and a second ultrasound receiver for receiving said transmitted ultrasound wave.
8. A method in accordance with claim 1, wherein said transducer sensor comprises a pressure sensor, and said wave comprises a pressure wave.
7. A method in accordance with claim 1, wherein said vessel is characterized by a tubular configuration, and wherein transducer sensor is disposed on the surface of said vessel.
8. A method in accordance with claim 1, wherein said transducer sensor comprises a thermal sensor, and said wave comprises a thermal wave.
9. A method for determining a two phase flow rate of a fluid mixture through a vessel, said fluid mixture comprising at least a first fluid component characterized by a first phase and a second fluid component characterized by a second phase, the method comprising:

- A. performing a tomography measurement of said fluid mixture flowing through said vessel, so as to determine a concentration ratio ρ of said first component to said second component in said fluid mixture;
- B. transmitting a first ultrasonic wave through said fluid mixture, and measuring the speed and direction of propagation of said first ultrasonic wave;
- C. transmitting a second ultrasonic wave through said fluid mixture, and measuring the speed and direction of propagation of said second ultrasonic wave; and
- D. computing said two phase flow rate of said fluid mixture using a known relationship between said two phase flow rate, said ratio ρ , and said speed and direction of propagation of each ultrasonic wave relative to the direction of flow of said fluid mixture.

10. A method in accordance with claim 9, wherein the direction of propagation of said first ultrasonic wave makes an angle $[\pi/2 - \theta]$ with respect to the direction of flow of said fluid mixture;
 wherein the direction of propagation of said second ultrasonic wave makes an angle $[\pi/2 + \theta]$ with respect to the direction of flow of said fluid mixture; and
 wherein said known relationship is given by:

$$v = \frac{\sin(\theta)}{2} \cdot (u_1 - u_2)$$

where

v is said two phase flow rate of said fluid mixture ;
 u_1 is said first approximate flow rate; and
 u_2 is said second approximate flow rate.

11. A method in accordance with claim 10,
 wherein said first approximate flow rate u_1 is given by:

$$u_1 = c_{mix} + \frac{1}{\sin(\theta)} v;$$

further wherein said second approximate flow rate u_2 is given by:

$$u_2 = c_{mix} - \frac{1}{\sin(\theta)} v;$$

further wherein c_{mix} is the speed of sound within the fluid mixture, and is given by:

$$c_{mix} = c_{first} \cdot \rho + c_{second} \cdot (1 - \rho),$$

where

c_{first} is the speed of sound within said first fluid component,

c_{second} is the speed of sound within said second fluid component,

and ρ is said concentration ratio of said first component to said second component.

12. A method in accordance with claim 9, wherein each of said first and second phases comprises at least one of: a solid; a liquid; and a gas.

13. A system for measuring a two phase flow rate of a fluid mixture flowing through a vessel, said fluid mixture containing at least a first component characterized by a first phase, and a second component characterized by a second phase, the system comprising:

- A. a tomography system for determining the concentration ratio between said first component and said second component within said fluid mixture;
- B. a first sensor for providing a first approximate flow measurement for said fluid mixture;
- C. a second sensor disposed at a known orientation relative to said first sensor, for providing a second flow measurement for said fluid mixture; and
- D. a processor for computing the two phase flow rate of said fluid mixture using said concentration ratio, said first flow measurement, and said second flow measurement; wherein said two phase flow rate is related to said concentration ratio and to said first and second flow measurements by a known relationship.

14. A system in accordance with claim 13, wherein said first and second sensors each comprise:

- a. a transmitter for transmitting a wave through said fluid mixture; and
- b. a receiver for detecting said transmitted wave.

15. A system in accordance with claim 14, wherein said two phase flow rate is a function of the direction and speed of transmission of said energy.
16. A system in accordance with claim 13, wherein said first and said second sensors comprise at least one of: an ultrasound sensor; a pressure sensor; and a thermal sensor.
17. A system in accordance with claim 14, wherein said energy comprises at least one of: a) an ultrasound wave; b) a pressure wave; and c) a thermal wave.
18. A system in accordance with claim 13, wherein
- a) said first sensor comprises a first ultrasound sensor for providing said first flow measurement;
 - b) said second sensor comprises a second ultrasound sensor for providing said second flow measurement; and
- wherein said energy comprises a first ultrasound wave propagating at an angle with respect to the direction of flow of said fluid mixture, and a second ultrasound wave propagating at another angle with respect to the direction of flow of said fluid mixture.
19. A system in accordance with claim 18, wherein the direction of propagation of said first ultrasonic wave makes an angle [$\pi/2 - \theta$] with respect to the direction of flow of said fluid mixture;
- wherein the direction of propagation of said second ultrasonic wave makes an angle [$\pi/2 + \theta$] with respect to the direction of flow of said fluid mixture; and
- wherein said known relationship is given by:

$$v = \frac{\sin(\theta)}{2} \cdot (u_1 - u_2),$$

where

v is said two phase flow rate of said fluid mixture ;
 u_1 is said first approximate flow rate; and
 u_2 is said second approximate flow rate.

20. A system in accordance with claim 19,
wherein said first approximate flow rate u_1 is given by:

$$u_1 = c_{mix} + \frac{1}{\sin(\theta)} v;$$

further wherein said second approximate flow rate u_2 is given by:

$$u_2 = c_{mix} - \frac{1}{\sin(\theta)} v;$$

further wherein c_{mix} is the speed of sound within the fluid mixture, and is given by:

$$c_{mix} = c_{first} \cdot \rho + c_{second} \cdot (1 - \rho),$$

where

c_{first} is the speed of sound within said first fluid component,

c_{second} is the speed of sound within said second fluid component,

and ρ is said concentration ratio of said first component to said second component.

21. A system in accordance with claim 18, wherein said first and second ultrasound sensor each comprises: an ultrasound transmitter for generating an ultrasound wave and transmitting it through said fluid mixture, and an ultrasound receiver for receiving said ultrasound wave.

22. A system in accordance with claim 13, wherein said tomography system comprises an ECT (Electrical Capacitance Tomography) system for providing a distribution of dielectric permittivity within said vessel by measuring the electrical capacitances between one or more pairs of electrodes placed around said vessel.

23. A system in accordance with claim 13, wherein said vessel is characterized by a tubular configuration.

24. A system in accordance with claim 13, wherein said vessel includes at least one bend.